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Consumption Behavior, Annuity Income and Mortality Risk of Retirees

Vesile Kutlu-Koc[1] · Rob Alessie[2] · Adriaan Kalwij[3]

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Abstract Previous empirical studies have found that individuals do not draw down their assets after retirement which is at odds with the predictions of a simple life cycle model without uncertainty. Hurd (Econometrica 57(4):779–813, 1989; Mortality risk and consumption by couples, 1999) explains such saving behavior of retired singles and couples by adding lifetime uncertainty to the simple life cycle model. We tested whether predictions about consumption during retirement of this extended life cycle model hold for a sample of older Americans. We used data from the Health and Retirement Study supplemented with data from the Consumption and Activities Mail Survey. In line with theory we found that, on average, total consumption is greater than their annuity income after retirement and that this difference increases with the level of initial wealth. For older singles but not for couples our results suggest that, as predicted by the extended theoretical model of Hurd, the on average negative consumption growth decreases with higher mortality rates.

Keywords Life cycle model · Consumption · Mortality risk

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1 Introduction

A simple life cycle model without uncertainty predicts that rational agents' level of consumption is determined by their lifetime income. Under the assumption that individuals' annual earned income is greater than their annual retirement income, this model implies that individuals save when they are young and draw down their assets after retirement. Studies such as Poterba et al. (2011) and Van Ooijen et al. (2015) have shown that the prediction of declining wealth with increasing age is not supported by the empirical evidence. Even for people at advanced ages these studies found no evidence in favor of wealth decumulation. Various extensions of the simple life cycle model have been developed to explain this inconsistency. Hurd (1989, 1999) explained saving behavior of elderly singles and couples by adding uncertainty about the date of death and bequest motives. Hubbard et al. (1994) found that when uncertainty about lifetime earnings and out-of-pocket medical expenditures are taken into account, the predictions of the model matched the observed trajectories of wealth and consumption more closely. Börsch-Supan and Stahl (1991) assumed that the individuals' marginal utility of consumption is affected by their health status and, therefore, in their model individuals become consumption constrained due to deteriorating health in old age and, therefore, individuals do not take up (all) their savings.

This paper's main contribution to the literature is that it empirically tests the predictions of the life cycle models proposed by Hurd (1989, 1999) by analyzing data on consumption. Hurd (1989) derives a model of consumption with mortality risk and bequest motives for retired singles who enter the retirement phase with positive wealth. His model without a bequest motive predicts that the (negative) growth rate of consumption decreases as the mortality rate increases as higher mortality rates make people more impatient and increase current consumption at the expense of future consumption. Moreover, this model predicts that wealth declines with age after retirement. This prediction implies that annuity income never exceeds consumption.

Hurd (1999) also developed a theoretical model to explain the consumption behavior of elderly couples. His model takes into account the mortality risk of both spouses, allows for bequest motives and predicts that the (negative) growth rate of consumption declines at a faster rate as the mortality risk of the couple increases at advanced ages.

Hurd's (1999) model for couples has not been empirical tested in previous studies. The theoretical life cycle model for couples also predicts that, unless individuals have a strong bequest motive, annuity income never exceeds consumption. We empirically test this prediction both for singles and couples by using 5 waves (2000, 2002, 2004, 2006, 2008) of the Health and Retirement Study (HRS) supplemented with the Consumption and Activities Mail Survey (CAMS). We test as well the theoretical prediction that a higher the level of initial wealth is associated with a larger difference between total consumption and annuity income.

Next, we test the prediction regarding consumption growth and mortality risk for elderly singles as well as for elderly couples. For elderly singles this prediction has already been tested by Salm (2010). He only used the 2000 and 2002 wave of the HRS.

His results confirm the validity of the model of Hurd (1989): consumption growth for elderly singles decreases by 1.8% point when the subjective mortality rate increases by 1% point. We will check whether the results of Salm still hold if one takes more recent waves of the HRS into account. We adapt the life cycle model for couples proposed by Hurd (1999) in such a way it can be brought to the data. In particular, our adaption allows for a solution for consumption growth which is independent of the widower's and the widow's marginal utilities of wealth and results in a model that can be estimated directly using the subjective survival probabilities of both the husband and wife.

The paper is structured as follows: Section 2 outlines the theoretical models. Section 3 describes the data and the descriptive statistics. Section 4 presents the estimation results, and Sect. 5 offers some concluding remarks.

2 Theoretical Models

2.1 The Singles Model

Hurd (1989) analyzes a consumption model with mortality risk and bequest motives for elderly singles. As mentioned above, we do not model employment and retirement decisions and focus on the retirement phase of individuals. Households enter retirement with a non-negative amount of assets. They moreover receive annuity income to finance consumption during retirement. Annuities are predetermined at retirement and real annuity income per year is assumed to be constant over time and denoted by y. Mortality risk is the only source of uncertainty. In order to fully understand the model of Hurd, we have to introduce some notation. Let a_τ^υ be the probability that a person survives until age τ given that he/she is alive at age υ ($\tau \geq \upsilon$) and m_τ^υ the probability that a person is dead at age τ given that he/she is alive in at age υ. Suppose that the retirement phase starts at age R and lasts at most until L, the maximum age after which the person dies with certainty, i.e. $m_{L+1}^L = 1$. Hurd (1989) assumes that the consumers maximize in each period t of the retirement phase ($t \in \{1, \ldots, L+1-R\}$) the following expected intertemporal utility function[1]:

$$\sum_{\tau=t}^{L+1-R} (1+\rho)^{t-\tau} a_{R+\tau-1}^{R+t-1} u(c_\tau) + \sum_{\tau=t}^{L+1-R} (1+\rho)^{t-1-\tau} m_{R+\tau}^{R+t-1} V((1+r)A_\tau) \qquad (1)$$

where r denotes the real interest rate, ρ the rate of time preference, c_τ consumption in period τ (at age $R+\tau-1$) and A_τ net worth (bequeathable wealth) at the end of period τ. The within period utility function $u(.)$ is assumed to be strictly concave and increasing in its argument. $V(.)$ denotes the utility from a bequest and it is increasing in A_τ.

The first term in Eq. (1) is the expected discounted utility from consumption. The second term is the expected discounted utility from leaving a bequest. The utility of leaving a bequest is a function of the net worth at the beginning of period $\tau+1$, i.e.

[1] $t = 1$ denotes the start of the retirement phase, i.e. in period 1 the individual is R years old.

$(1+r)\,A_{\tau}$. The intertemporal utility function in Eq. (1) is maximized subject to the following asset accumulation constraints and the liquidity constraints:

$$A_{\tau} = (1+r)\,A_{\tau-1} + y - c_{\tau}, \quad \tau = 1, \ldots, L+1-R \tag{2a}$$

$$A_{\tau} \geq 0, \quad \tau = 1, \ldots, L+1-R \tag{2b}$$

where y is non-capital income (in real terms), consisting only of annuities. Equation (2b) states that individuals cannot borrow without collateral. In other words, individuals cannot borrow against future Social Security or pension income. Consequently, private wealth and annuity wealth are not perfect substitutes.

If we ignore the liquidity constraints (2b), the first order condition of this maximization can be written as ($t \in \{1, \ldots, L-R\}$):

$$u'(c_t) = \frac{1+r}{1+\rho}\left(\left(1 - m_{R+t}^{R+t-1}\right) u'(c_{t+1}) + m_{R+t}^{R+t-1} V'((1+r)\,A_{\tau})\right) \tag{3}$$

where $u'(.)$ is the marginal utility of consumption in period t, and $V'(.)$ is the marginal utility of leaving a bequest in period t. Equation (3) is an Euler equation that describes the allocation of resources over time under lifetime uncertainty. In the case of a constant relative risk aversion (CRRA) utility function, i.e. $u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$, and no bequest motive ($V'(.) = 0$) Eq. (3) becomes

$$\left(\frac{c_{t+1}}{c_t}\right)^{\gamma} = \frac{1+r}{1+\rho}\left(1 - m_{R+t}^{R+t-1}\right), \tag{4}$$

where γ is the coefficient of relative risk aversion. After taking the natural logarithm of both sides, Eq. (4) can be rewritten as

$$\Delta \ln c_{t+1} = \frac{1}{\gamma} \ln\left(\frac{1+r}{1+\rho}\right) + \frac{1}{\gamma} \ln\left(1 - m_{R+t}^{R+t-1}\right), \tag{5}$$

where $\Delta \ln c_{t+1} = \ln c_{t+1} - \ln c_t$.

Equation (5) shows that consumption growth increases with a higher real interest rate and that it decreases with a higher rate of time preference and a higher subjective mortality rate. Consumption growth is negative if individuals are impatient ($\rho > r$) since they prefer consuming today rather than consuming tomorrow. Since the mortality rate increases exponentially with age, individuals behave even more impatient as they become older and, accordingly, their consumption declines at a faster rate. Individuals who are relatively more risk averse will have a flatter than average consumption profile and their consumption will decline at a relatively slower rate with increasing age.

This model assumes that individuals enter the retirement period with a positive amount of assets and, therefore, are not liquidity constrained at the beginning of the retirement period. However, they draw down their assets as they consume more than their annuity income and may become constrained after some time when having drawn

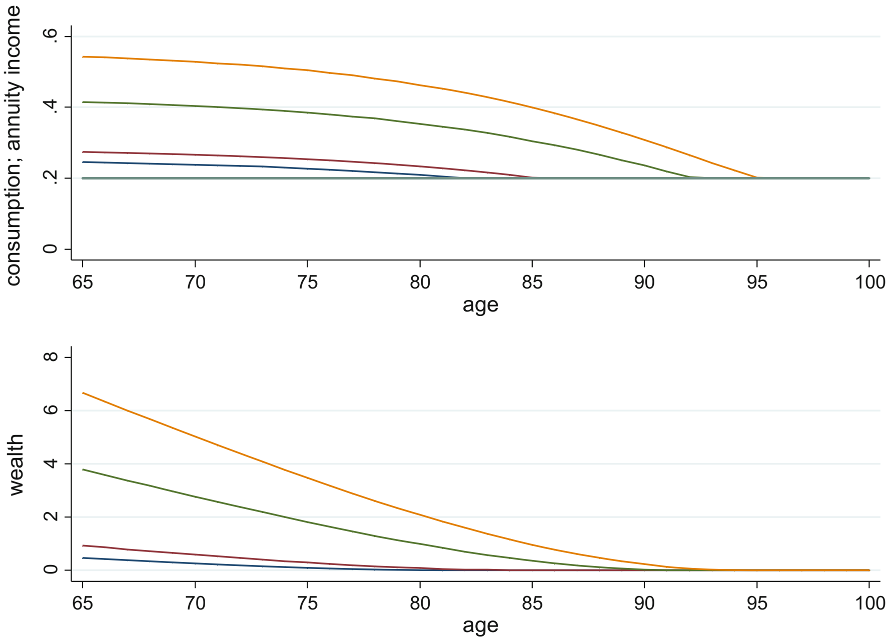

Fig. 1 Consumption and (private) wealth in a model without bequests for different levels of initial wealth ($R = 65,\ y = 0.2; r = \rho = 0.001; \gamma = 3$)

down their assets to zero at a certain period t^* ($A_\tau = 0,\ \tau = t^*, \ldots, L + 1 - R$). In that case, consumption will be equal to annuity income from t^* onward. This is illustrated in Fig. 1.

The flat line in this figure stands for the constant annuity stream after retirement. As a result, this model predicts that consumption is never smaller than annuity income, ($c_t > y$). This prediction still holds if we would add additional uncertainty to the model such as uncertainty about out-of-pocket medical expenses (De Nardi et al. 2010). However, if people have a (strong) bequest motive, consumption may not exceed annuity income. This latter prediction may as well not hold when the marginal utility of consumption depends on health status (Börsch-Supan and Stahl 1991). This figure also shows that different consumption profiles can be obtained for different levels of initial wealth. The level of consumption is an increasing function of initial wealth and the difference between total consumption and annuity income depends on the level of initial wealth, i.e. the higher the initial wealth, the bigger this difference is. The wealth-age profile is much steeper for a high level of initial wealth which suggests that at the early stage of the retirement phase consumption is considerably larger than the annuity income. The wealth-age profile is rather flat for a low level of initial wealth and individuals draw down their assets at a relatively slow rate.

2.2 The Couples Model

Hurd (1999) proposes a consumption model with mortality risk and bequest motives for elderly couples. In this model a couple receives utility from consumption and from leaving bequests. There are two types of bequests. The remaining wealth is first transferred to the surviving spouse and after the death of the surviving spouse the by then remaining wealth is inherited by children or others. This model is an extension of the singles model and all assumptions of the singles model are maintained. Both spouses are retired and $t = 1$ denotes the first period that both spouses are retired. We allow for an age difference between the husband and wife and at $t = 1$ the husband has age R_m and the wife has age R_f. R^* and $\tilde{R}$ denote the ages of the oldest and youngest spouse, respectively: $R^* = \max\left(R_m, R_f\right)$ and $\tilde{R} = \min\left(R_m, R_f\right)$. The retired couple maximizes the following expected utility function starting from period t onwards until the certain time of death of the surviving spouse, $L + 1 - \tilde{R}$. We allow for different mortality rates between men and women but assume that the maximum age after which the person dies with certainty, L, is the same for men and women. In each period t of the retirement phase ($t \in \{1, \ldots, L + 1 - R\}$) households maximize the following expected intertemporal utility function:

$$\begin{aligned}
&\sum_{\tau=t}^{L+1-R^*} (1+\rho)^{t-\tau} \tilde{a}_\tau^t u\left(c_\tau\right) + \sum_{\tau=t}^{L+1-R_m} (1+\rho)^{t-1-\tau} \tilde{h}_{\tau+1}^t F\left((1+r) A_\tau\right) \\
&\quad + \sum_{\tau=t}^{L+1-R_f} (1+\rho)^{t-1-\tau} \tilde{w}_{\tau+1}^t M\left((1+r) A_\tau\right) \\
&\quad + \sum_{\tau=t}^{L+1-\tilde{R}} (1+\rho)^{t-1-\tau} \check{m}_{\tau+1}^t V\left((1+r) A_\tau\right),
\end{aligned} \tag{6}$$

where $u\left(c_\tau\right)$ is the couple's utility from consumption, $M\left((1+r) A_\tau\right)$ is the widower's utility of wealth, $F\left((1+r) A_\tau\right)$ is the widow's utility of wealth and $V(.)$ is the utility from leaving a bequest. The probability that both spouses will be alive in period τ given that they survive to period t is denoted by $\tilde{a}_\tau^t$. This probability is equal to

$$\tilde{a}_\tau^t = \prod_{k=t}^{\tau-1} \left(1 - \tilde{m}_{k+1}^k\right), \tag{6a}$$

where $\tilde{m}_{t+1}^t$ is the instantaneous mortality rate of the couple which is the probability that one of the spouses dies at the beginning of period $t+1$ given that both spouses were alive in the previous period. This probability, is the sum of mortality risk of the wife, $w_{R_f+t+1}^{R_f+t}$, and mortality risk of the husband, $h_{R_m+t+1}^{R_m+t}$, minus the probability that both spouses die in period $t + 1$ given that both spouses were alive in the previous period:

$$\tilde{m}_{t+1}^t = w_{R_f+t+1}^{R_f+t} + h_{R_m+t+1}^{R_m+t} - w_{R_f+t+1}^{R_f+t} \cdot h_{R_m+t+1}^{R_m+t}. \tag{6b}$$

This equation shows that we assume that the death of the husband is independent of the death of the wife. Notice that the instantaneous mortality rate of the couple depends on the ages of husband ($R_m + t$) and wife ($R_f + t$) in the period t. In Eq. (6) $\tilde{w}_{\tau+1}^t$

denotes the probability that the husband becomes a widower, i.e. the wife dies and the husband remains alive, at the beginning of period $\tau + 1$:

$$\tilde{w}^t_{\tau+1} = \prod_{k=t}^{\tau-1} \left(1 - \tilde{m}^k_{k+1}\right) \cdot \left(w^{R_f+\tau}_{R_f+\tau+1} - w^{R_f+\tau}_{R_f+\tau+1} \cdot h^{R_m+\tau}_{R_m+\tau+1}\right), \quad \mathit{for}\ \tau > t$$
$$\tilde{w}^t_{t+1} = \left(w^{R_f+t}_{R_f+t+1} - w^{R_f+t}_{R_f+t+1} \cdot h^{R_m+t}_{R_m+t+1}\right) \quad \mathit{for}\ \tau = t. \tag{6c}$$

Likewise, $\tilde{h}^t_{\tau+1}$ is the probability that the wife becomes a widow at the beginning of period $\tau + 1$:

$$\tilde{h}^t_{\tau+1} = \prod_{k=t}^{\tau-1} \left(1 - \tilde{m}^k_{k+1}\right) \cdot \left(h^{R_m+\tau}_{R_m+\tau+1} - w^{R_f+\tau}_{R_f+\tau+1} \cdot h^{R_m+\tau}_{R_m+\tau+1}\right) \quad \mathit{for}\ \tau > t,$$
$$\tilde{h}^t_{t+1} = \left(h^{R_m+t}_{R_m+t+1} - w^{R_f+t}_{R_f+t+1} \cdot h^{R_m+t}_{R_m+t+1}\right) \quad \mathit{for}\ \tau = t. \tag{6d}$$

$\check{m}^t_{\tau+1}$ is the probability that both spouses die at the beginning of period $\tau + 1$:

$$\check{m}^t_{\tau+1} = \prod_{k=t}^{\tau-1} \left(1 - \tilde{m}^k_{k+1}\right) \cdot \left(w^{R_f+\tau}_{R_f+\tau+1} \cdot h^{R_m+\tau}_{R_m+\tau+1}\right) \quad \mathit{for}\ \tau > t,$$
$$\check{m}^t_{t+1} = \left(w^{R_f+t}_{R_f+t+1} \cdot h^{R_m+t}_{R_m+t+1}\right) \quad \mathit{for}\ \tau = t. \tag{6e}$$

The utility function in Eq. (6) is maximized subject to the asset accumulation constraints and the liquidity constraints as introduced in the singles problem:

$$A_\tau = (1 + r)\, A_{\tau-1} + y_\tau - c_\tau, \quad \tau = t, \ldots, L + 1 - \tilde{R}, \tag{7a}$$
$$A_\tau \geq 0, \quad \tau = t, \ldots, L + 1 - \tilde{R}. \tag{7b}$$

The solution of this model depends on the widower's marginal utility of wealth $M'\left((1 + r)\, A_\tau\right)$ and the widow's marginal utility of wealth $F'\left((1 + r)\, A_\tau\right)$ (Hurd 1999; equation 5, p. 16). In order to estimate this model, one should explicitly define these marginal utilities. We specify the unitary model proposed by Hurd (1999) somewhat further by making explicit assumptions about economies of scale (equivalence scale) and about the widow(er)'s utility of wealth. This model allows us to find a solution which is independent of the widower's and the widow's marginal utilities of wealth so that it can be estimated directly using the subjective survival probabilities of the husband and the wife. In our model the couple maximizes the following expected utility function starting from the beginning of the retirement phase, $t = 1$, until the certain time of death of the surviving spouse, $t = L + 1 - \tilde{R}$:

$$\sum_{\tau=t}^{L+1-R^*} (1+\rho)^{t-\tau} \tilde{a}_\tau^t u\left(\frac{c_\tau}{\sqrt{2}}\right) + \sum_{\tau=t}^{L+1-R_m} (1+\rho)^{t-1-\tau} \tilde{h}_{\tau+1}^t F\left((1+r) A_\tau\right)$$
$$+ \sum_{\tau=t}^{L+1-R_f} (1+\rho)^{t-1-\tau} \tilde{w}_{\tau+1}^t M\left((1+r) A_\tau\right)$$
$$+ \sum_{\tau=t}^{L+1-\tilde{R}} (1+\rho)^{t-1-\tau} \check{m}_{\tau+1}^t V\left((1+r) A_\tau\right), \tag{8}$$

where $u\left(\frac{c_\tau}{\sqrt{2}}\right)$ shows the couple's utility from consumption divided by the 'square root' equivalent scale (OECD 2008). $M\left((1+r) A_\tau\right)$ is the widower's utility of wealth which we assume to be equal to $\sum_{k=\tau+1}^{L+1-R_m} (1+\rho)^{\tau+1-k} a_{R_m+k}^{m,R_m+\tau+1} u(c_\tau)$ and, likewise, we assume that the widow's utility of wealth $F\left((1+r) A_\tau\right)$ equals $\sum_{k=\tau+1}^{L+1-R_f} (1+\rho)^{\tau+1-k} a_{R_f+k}^{f,R_f+\tau+1} u(c_\tau)$. Notably, we make the assumption underlying the unitary model that the within period utility function is the same for couples, widows and widowers. Admittedly, this is a strong assumption which makes it possible to derive a relatively simple expression for the Euler equation (see below). The utility function in Eq. (8) is maximized subject to the asset accumulation constraints and the liquidity constraints in (7a) and (7b).

In case of no bequest motive to the children or others and no liquidity constraints, we solved the couple's maximization problem and find the following Euler equation[2]:

$$u'\left(\frac{c_t}{\sqrt{2}}\right) = \left(\frac{1+r}{1+\rho}\right)\left[\left(1-\tilde{m}_{t+1}^t\right) u'\left(\frac{c_t}{\sqrt{2}}\right) + \sqrt{2}\left(\tilde{h}_{t+1}^t + \tilde{w}_{t+1}^t\right) u'(c_t)\right] \tag{9}$$

where $\tilde{m}_{t+1}^t$ is the instantaneous mortality rate of the couple as defined in Eq. (6b). $\tilde{w}_{t+1}^t$ is the probability that the husband becomes a widower at the beginning of period $t+1$ (see Eq. 6c). Similarly, $\tilde{h}_{t+1}^t$ is the probability that the wife becomes a widow at the beginning of period $t+1$ (see Eq. 6d).

In case of a CRRA within period utility function, Eq. (9) becomes:

$$\left(\frac{c_{t+1}}{c_t}\right)^\gamma = \left(\frac{1+r}{1+\rho}\right)\left[\left(1-\tilde{m}_{t+1}^t\right) + \sqrt{2}^{1-\gamma}\left(\tilde{h}_{t+1}^t + \tilde{w}_{t+1}^t\right)\right] \tag{10}$$

After taking the natural logarithm of both sides, Eq. (10) can be written as:

$$\Delta \ln c_{t+1} = \frac{1}{\gamma} \ln\left(\frac{1+r}{1+\rho}\right) + \frac{1}{\gamma} \ln\left(1 - \left(\tilde{m}_{t+1}^t - \sqrt{2}^{1-\gamma}\left(\tilde{h}_{t+1}^t + \tilde{w}_{t+1}^t\right)\right)\right) \tag{11}$$

We refer to the term inside the logarithm, $\left(\tilde{m}_{t+1}^t - \sqrt{2}^{1-\gamma}\left(\tilde{h}_{t+1}^t + \tilde{w}_{t+1}^t\right)\right)$, as the couple's mortality rate and one can show that it is positive as long as the coefficient of

[2] Hurd (1999, p. 16) points out that the Euler equation does not include the marginal utility of leaving a bequest to the children since the probability that both spouses die in the near future is close to zero.

risk aversion is larger than one and it increases with an increase in the mortality rates of the wife and the husband. Equation (11) shows, therefore, that the consumption growth of a couple declines with an increase in the couple's mortality rate when they become older. In the empirical part of this paper we take Eq. (11) as starting point of our analysis. We assume that the coefficient of risk aversion is equal to three, which is a reasonable value obtained by the previous studies (e.g. Palumbo 1999), and calculate the couple's mortality rate accordingly. In this case the couple's mortality rate is equal to the average of wife's and husband's mortality rate, i.e.

$$\tilde{m}_{t+1}^{t} - \sqrt{2}^{1-3}\left(\tilde{h}_{t+1}^{t} + \tilde{w}_{t+1}^{t}\right) = \frac{1}{2}\left(h_{R_m+t+1}^{R_m+t} + w_{R_f+t+1}^{R_f+t}\right). \tag{11a}$$

3 The Data

The HRS is a biennial panel survey of Americans and its respondents were first interviewed in 1992 (Juster and Suzman 1995). The HRS is well-suited for the purpose of our study since it is a large sample of elderly population and it includes detailed information on employment status, annuity income, household wealth, marital status, subjective survival probabilities, and health status of the respondents and their spouses. The data on consumption come from the Consumption and Activities Mail Survey (CAMS) which is a supplemental survey to the HRS. In 2001 the CAMS survey sent questionnaires to a subsample of the households who were interviewed in the HRS 2000 core survey. If household members are married or have a partnership, the questionnaire was sent to one of the spouses, selected randomly. In the initial wave of the CAMS survey 3866 households answered questions about household spending in 26 categories of nondurables and six categories of durables (see Hurd and Rohwedder 2008 for details). This survey has smaller number of households than the HRS and covers the period from 2001 to 2011.

We have used five waves of the CAMS survey covering the years 2001–2009. The CAMS survey was matched to most of the information in the previous HRS wave, i.e. CAMS 2001 was matched to the HRS 2000. However, information on financial variables such as wealth and income has been obtained from the next HRS wave. For example, HRS 2002 has information on total income for the year 2001 which coincides with the information on consumption in CAMS 2001.[3]

Individuals' annuity income (before-tax) has been defined as the sum of income from employer pension and/or annuity, social security disability, supplemental security income, social security retirement, spouse or widow benefits, unemployment and worker's compensation, and other income including veteran's benefits, welfare and food stamps. After-tax annuity income was obtained by deducting total taxes paid (federal taxes, state taxes, and the Federal Insurance Contributions Act (FICA) tax which includes social security tax and Medicare tax) from before-tax annuity income. Federal taxes, state income taxes, and the FICA tax for each household in each year have been

[3] We excluded CAMS 2011 from our analysis as HRS 2012 was not available when we carried out our analysis.

calculated based on the NBER tax calculator TAXSIM (Feenberg and Coutts 1993). Given respondents background characteristics such as their marital status, income from all sources, deductions etc., this program calculated the tax liabilities for each household in our sample.[4]

To measure individuals' mortality risks we use subjective mortality rates instead of life table mortality rates because of two reasons. First, life table mortality rates do not show much individual variation since they are aggregated and allow only for differences by age, gender and race, while subjective mortality rates are on an individual level. Previous studies have shown that subjective mortality rates are correlated with individual characteristics such as level of education, wealth, and income, as well as behavioral factors such as smoking, alcohol consumption and obesity (Hurd and McGarry 2002). Consequently, subjective mortality rates are more informative about individuals' mortality rates than life table mortality rates. For instance, smokers may know they are likely to die earlier than an average person in the population and behave accordingly. In this case, life table mortality rates may not predict smokers' saving and consumption decisions well. Second, individuals may make decisions based on their beliefs of survival and these beliefs do not necessarily have to be the same as objective survival rates. While deviations of subjective from objective survival rates would yield suboptimal decisions, they may more actuarily explain observed behavior.

Subjective mortality rates for each respondent and his/her spouse (if present) are calculated in each wave from 2000 to 2008 based on a question about individuals' probability of survival to a certain age. The question is:

> [Using any] number from 0 to 100 where "0" means that you think there is absolutely no chance and "100" means that you think the event is absolutely sure to happen…What is the percent chance that you will live to be 80/85/90/95/100) or more?[5]

Hurd and McGarry (2002) have shown that these probabilities are good predictors of individuals' actual mortality within a sample, i.e. individuals who expect to live longer are less likely to die. Following Gan et al. (2003) and Salm (2010) we derived annual subjective mortality rates by assuming that individuals' subjective mortality rate ($m_{i,\tau}^{\tau-1}$) is proportionate to the life table mortality rate ($m_{0,\tau}^{\tau-1}$) as follows:

$$m_{i,\tau}^{\tau-1} = \xi_i m_{0,\tau}^{\tau-1}, \quad \tau = t+1, t+2, \ldots, L+1 \tag{12}$$

Under this assumption, the subjective probability $s_{i,t,T}$ of individual i to survive from age t to age T becomes:

$$s_{i,t,T} = \prod_{\tau=t-1}^{T-1} \left(1 - m_{i,\tau+1}^{\tau}\right) = \prod_{\tau=t-1}^{T-1} \left(1 - \xi_i m_{0,\tau+1}^{\tau}\right) \tag{13}$$

[4] For more information see http://hrsonline.isr.umich.edu/index.php?p=shownews3x1&hfyle=news198.

[5] The target age is always more than ten years above the respondents' current age.

The individual mortality factor ξ_i is obtained from minimizing for each individual:

$$\min_{\xi_i} \left(s_{i,t,T} - \prod_{\tau=t-1}^{T-1} \left(1 - \xi_i m_{0,\tau+1}^{\tau}\right) \right)^2 \tag{14}$$

This method does not produce meaningful mortality factors if individuals reported zero or one answers to probability of survival to age T. For this reason, we recoded the probability responses 0 and 1 to, respectively, 0.01 and 0.99 (see e.g Salm 2010). Life table mortality rates are taken from race, gender, and age specific life-tables of National Vital Statistics Reports which are available for the years from 2000 to 2008.

3.1 Sample Selection

The CAMS survey has questions about household spending which are answered by the respondents who also participated in the HRS core survey in 2000. If two respondents are married or have a partnership, one of the spouses has been selected randomly to answer the questions about household spending. We started with an unbalanced panel sample which includes households who answered questions in the CAMS survey at least one time in the period from 2001 to 2009. We restricted the sample to 3615 households in which the respondent and, if present, his/her spouse are aged 65 and over. By age 65 most individuals are retired and at age 65 individuals become eligible for Medicare. Nevertheless, as also observed in the data, some individuals have income from earnings after age 65. Since our study focuses on retired individuals, we therefore further restricted our sample to 3264 households in which the respondent and, if present, his/her spouse do not earn any wage income.

Next, we selected individuals who are not liquidity constrained in the sense that they hold positive amount of household wealth in the first year they entered the survey. This restriction is necessary because the models of Sect. 2 assume no liquidity constraints and our sample is selected accordingly to be able to test the models' predictions. After excluding households with zero or negative wealth holdings, we are left with 3033 households.

Finally, we selected the 2428 households which are one or two-person households. For the one-person household, the household size is equal to one and the household member is separated/divorced/widowed or never married. We refer to such households as singles. For the two-person household, the household size is equal to two and the household members are married or living with a partner. No children or other persons are present in these selected household. We refer to such households as couples. Some couples may have become singles during the observation period as a result of divorce, separation or the death of the spouse and our theoretical model of Sect. 2 allows for such a transition. However, as it does not match our models of Sect. 2, we removed 50 singles who became couples during the observation period, e.g. because of a (re)marriage. Missing information on subjective survival probabilities caused a further exclusion of 283 households and missing information on the change in nondurable consumption caused a further exclusion of 941 households. Our final sample includes 1154 households and 3692 household-year observations.

3.2 Definition of Variables and Descriptive Statistics

Table 1 displays the sample mean, median and standard deviation of financial variables for both singles and couples. Total consumption is the sum of durables and nondurables excluding spending on cars and mortgages.[6] Categories of durable consumption include refrigerator, washer/dryer, dishwasher, television, and computer and categories of nondurables are home insurance, property tax, rent, electricity, water, heat, home repair services, phone/cable/internet, auto insurance, health insurance, house/yard supplies, home repair supplies and services, food, dining out, clothing, gasoline, vehicle services, drugs, health services, medical supplies, vacations, tickets, hobbies, contributions, and gifts. Total consumption, after-tax annuity income, total net household wealth, total net financial wealth, and total health expenditures are measured at the household level. Total net household wealth excludes Individual Retirement Accounts (IRAs) and the value of 401k/Keogh plans and it is defined as the sum of all wealth components less all debt. The wealth components are the value of the primary residence, real estate, vehicles, stocks, checking accounts, government bonds, bonds, other wealth and the debt components are mortgages, home loans and other debt. Total net financial wealth does not include the value of the primary residence, real estate, mortgages, and home loans. Total health expenditures consist of expenditures on drugs, health services, medical supplies, and health insurance.

According to Table 1, there is a difference between sample mean and median values for some variables such as total consumption, wealth, and financial wealth which may suggest that some households have very high levels of wealth and/or consumption. The mean ratio of wealth to annuity income is 17, which suggests that the sample has very wealthy households. The ratio of total consumption to annuity income is larger than one. The variable "I (total consumption $\geq$ annuity income)" is an indictor function that takes one if total consumption is greater than or equal to after-tax annuity income and zero otherwise.

Table 2 shows the sample mean, median, and standard deviation of the variables used in the estimation of the Euler equation (Eq. 5) for singles. We focus on nondurable consumption categories because these are easier to adjust for consumers compared to durable consumption categories. Some of the nondurable expenditures such as home insurance, property tax, rent, electricity, water, heat, and auto insurance are essential for individuals and we may not expect that they change in response to changes in the subjective mortality risk. Medical expenditures can be seen as an investment in health and may not provide direct utility to individuals. Salm (2010) used seven categories of nondurables which are food, dining out, clothing, gasoline, vacations,

[6] These two spending categories contain components of savings. Individuals were asked to report total mortgage payments and total car payments which include both interest and principal. To find a pure spending measure for these two components, one needs to remove the saving component from the payments by subtracting the principle. Since the CAMS survey does not include information on principal and interest separately, we could not calculate the pure spending measures for these components.

Table 1 Summary statistics (one-person or two-person households)

	Mean	Median	SD
Total consumption (in 2003 dollars)	23,380	18,950	17,240
Annuity income (in 2003 dollars)	18,330	16,090	13,120
Wealth (in 2003 dollars)	289,240	156,730	590,680
Financial wealth (in 2003 dollars)	151,010	47,510	356,180
Total health expenditures (in 2003 dollars)	3510	2610	4100
Wealth/annuity income	17.243	8.37	41.474
Financial wealth/annuity income	8.974	2.418	27.982
Total consumption/annuity income	1.632	1.133	2.119
Total consumption minus annuity income	0.498	0.206	2.017
I (total consumption $\geq$ annuity income)	0.587	1	0.492
Age of the household respondent	74.827	75	6.426
Male	0.324	0	0.468
Number of observations (households)	3692 (1154)		

The financial variables measured at the household level and are divided by the OECD-modified equivalence scale (Hagenaars et al. 1994)

Table 2 Summary statistics (one-person households)

	Mean	Median	SD
Nondurable consumption (all categories)	21,992	17,968	15,381
Nondurable consumption (Salm 2010 categories)	5911	4666	5820
Nondurable consumption growth (all categories)	−0.022	−0.022	0.266
Nondurable consumption growth (Salm 2010 categories)	−0.042	−0.039	0.368
Subjective mortality rate	0.058	0.034	0.055
Life table mortality rate	0.047	0.039	0.03
Age	76.809	77	6.582
Male	0.212	0	0.408
Poor health	0.266	0	0.442
Good health	0.4	0	0.49
Years of education	12.517	12	2.475
Any ADL limitations	0.177	0	0.382
Any IADL limitations	0.369	0	0.482
CES-D score	1.566	1	1.877
Number of observations (households)	1323 (646)		

(1) All amounts are in 2003 dollars
(2) Annual growth rates are reported
(3) The number of observations takes into account that the estimation of the Euler equation requires at least two observations per household

tickets, hobbies. The latter categories are more easily adjusted in the short term if needed. In the empirical part of the study we consider both all categories and the categories of nondurables used by Salm (2010). Notice that that average nondurable consumption growth is negative. Under the assumption that the average individual is impatient, this result is in line with the singles model of Hurd if one ignores a bequest motive (cf. Eq. 5).

Good health is a binary indicator equal to one if individuals' self-rated health status is excellent and very good, and zero otherwise. Similarly, poor health is a binary variable which is equal to one if individual's self-reported health is fair or poor, and zero otherwise. "Any ADL limitations" is a binary variable which shows whether individuals have any difficulty in activities of daily living such as eating, bathing, walking across a room, dressing, getting in and out of bed, and using the toilet. The variable "Any IADL limitations" indicates whether individuals have any difficulty in Instrumental Activities of Daily Living task such as using a telephone, taking medication, handling money, shopping for groceries, preparing meals, and using a map. The score on the Center for Epidemiologic Studies Depression (CES-D) is a mental health index which is commonly used by psychologists as well as economists (Hao 2008; Finkelstein et al. 2008). The CES-D ranges from 0 to 8 and it is the sum of six negative indicators (depression, everything is an effort, sleep is restless, felt alone, felt sad, could not get going) minus two positive indicators (felt happy and enjoyed life); the higher the score, the more negative the respondent's feelings were in the past week.

Table 3 gives descriptive statistics of the variables used in the estimation of the Euler equation (Eq. 11) for couple households. Average non-durable consumption growth is also negative for couples as predicted by the couples model (assuming $\rho \geq r$, see Eq. 11).

Table 4 reports the levels of total consumption and nondurables consumption across years. According to this table, on average, both total and nondurables consumption have decreased over the years 2001–2009. The decline in consumption from 2007 to 2009 could, in part, be driven by the financial crisis which has affected the income and wealth of many people.

Table 5 reports the sample mean of a binary variable equal to one if total consumption is greater than or equal to after-tax annuity income, and zero otherwise, by different age groups. According to this table, for the majority of respondents, total consumption is greater than their annuity income, although there are some differences across years. For example, in 2009 we find that most respondents in the age groups 65–69 spent less than their annuity income. The reduction in consumption in this particular year could reflect the effect of the global financial crisis. Due to a strong stock market decline in 2009 individuals who just entered retirement might have experienced a loss in their financial assets, which could have caused them to consume less than their annuity income.

4 Estimation Results

The models outlined in Sect. 2 predict that total consumption is larger than annuity income and that this difference increases with an increase in the level of initial wealth

Table 3 Summary statistics (two-person households)

	Mean	Median	SD
Nondurable consumption (all categories)	34,156	27,996	23,509
Nondurable consumption (Salm 2010 categories)	10,764	8870	8349
Nondurable consumption growth rate (all categories)	−0.038	−0.023	0.254
Nondurable consumption growth rate (Salm 2010 categories)	−0.051	−0.052	0.318
Husband's subjective mortality rate	0.053	0.034	0.049
Wife's subjective mortality rate	0.041	0.025	0.045
The couple's mortality rate, subjective[a]	0.048	0.033	0.037
The couple's mortality rate from the life table[a]	0.04	0.034	0.02
Age_husband	75.78	75	5.216
Age_wife	73.29	73	5.034
Poor health_husband	0.224	0	0.417
Poor health_wife	0.199	0	0.4
Good health_husband	0.434	0	0.495
Good health_wife	0.441	0	0.496
Years of education_husband	12.99	12	3.116
Years of education_wife	12.79	12	2.311
Any ADL limitations_husband	0.111	0	0.314
Any ADL limitations_wife	0.119	0	0.324
Any IADL limitations_husband	0.344	0	0.475
Any IADL limitations_wife	0.263	0	0.44
CES-D score_husband	0.766	0	1.249
CES-D score_wife	1.048	0	1.521
Number of observations (households)	1061 (524)		

(1) All amounts are in 2003 dollars
(2) annual growth rates are reported
(3) The number of observations takes into account that the estimation of the Euler equation requires at least two observations per household
[a] This is defined as the average of the husband's and wive's mortality rate (see Eq. 11a)

Table 4 Equivalised total consumption per household across years (in 2003 dollars)

Year	No. obs.	Total consumption		Nondurables consumption		Nondurables consumption (Salm 2010 categories)	
		Mean	Median	Mean	Median	Mean	Median
2001	583	25,669	20,064	25,359	19,605	7302	5339
2003	747	24,955	20,686	24,619	20,298	7134	5640
2005	826	22,723	18,155	22,440	17,968	6997	5229
2007	872	22,789	18,738	22,400	18,403	6758	5393
2009	664	20,684	17,500	20,125	17,312	5719	4821

Number of observations (households): 3692 (1154)

Table 5 The proportion of households with consumption greater than, or equal to, annuity income by age groups and years

Age class	Mean	No. obs.	Mean	No. obs.
2001			2003	
65–69	0.649	154	0.606	158
70–74	0.673	141	0.639	177
75–79	0.63	156	0.582	175
80–83	0.649	102	0.686	162
85+	0.657	30	0.723	75
2005			2007	
65–69	0.528	178	0.543	180
70–74	0.453	203	0.548	215
75–79	0.61	187	0.6	215
80–83	0.603	164	0.596	157
85+	0.638	94	0.622	105
2009			2001–2009	
65–69	0.426	89	0.562	759
70–74	0.503	165	0.556	901
75–79	0.516	180	0.588	913
80–83	0.592	135	0.623	720
85+	0.6	95	0.641	399

In case of couples age is of the respondent who answered the questions about the household consumption

(see Fig. 1). We test this prediction by regressing the logarithm of total consumption minus logarithm of annuity income on age, initial wealth and health characteristics. The estimation results of this regression for singles in Table 6, first column, show that the coefficient of wealth is positive and statistically significant. This suggests that the higher the level of wealth, the larger the difference between total consumption and annuity income is. In other words, singles are more likely to spend more than their annuity income and this additional spending is higher for those who enter retirement with more (initial) wealth. The results also indicate a significant age effect after controlling for year-of-birth cohort effects. As individuals draw down their wealth after retirement, their total consumption converges to annuity income at advanced ages as predicted by the model of Hurd (see Fig. 1). Another interesting finding is the higher educated have a larger difference between total consumption and annuity income.

The bottom of the table (the Wald test) shows that the health variables are jointly significant at a 5% level. Specifically, being in poor health significantly increases total consumption relative to annuity income, which could be because total consumption includes health expenditures. In support of this explanation, the results in the second column of Table 6 show that the logarithm of total health expenditures is significantly higher for those who are in poor health. Once health expenditures are excluded from total expenditures, the difference between total consumption and annuity income becomes independent of individuals' health status.[7] The results in the second column suggest as well that the logarithm of total health expenditures becomes higher as

[7] Results are available upon request.

Table 6 Explaining differences between consumption and annuity income, one-person households

Model	(1) Log total consumption minus log annuity income	(2) Log total health expenditures
Year of birth	−0.023***	−0.051***
	(0.005)	(0.009)
Age	−0.019***	−0.032***
	(0.005)	(0.009)
Wealth (in $10,000)	0.003***	0.003***
	(0.001)	(0.001)
CES-D score	0.014	0.012
	(0.011)	(0.016)
Poor health	0.110**	0.167**
	(0.045)	(0.079)
Good health	0.016	−0.088
	(0.041)	(0.061)
Any ADL limitations	0.008	0.046
	(0.049)	(0.085)
Any IADL limitations	0.04	−0.011
	(0.041)	(0.066)
Years of education	0.023***	0.066***
	(0.008)	(0.015)
Constant	47.29***	108.3***
	(11.58)	(18.12)
Number of observations (households)	1995 (646)	1941(645)
Wald test all health variables, p value	0.015	0.017

Robust standard errors in parentheses * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

the level of education increases. An explanation for this latter finding might be that although high educated individuals are usually healthier than low educated individuals, hence have less spending on health, low-income individuals in the United States are covered by a social health care program called Medicaid whereas high-income individuals are not and may, therefore, have relatively higher out-of-pocket expenditures.

Similar to findings for singles, Table 7 shows that for couples the level of initial wealth is positively associated with the difference between total consumption and annuity income. The age effect in this model is not as strong as in the singles model. Neither the age of husband nor the age of wife has a significant effect on the difference between total consumption and annuity income. One explanation can be that couple households are usually younger than single person households and, therefore, they may have a flatter consumption profile. The p-value of the Wald test for health variables at the bottom of the table shows that the health variables have jointly insignificant effects.

Table 7 Explaining differences between consumption and annuity income,two-person households

Model	(1) Log total consumption minus log annuity income	(2) Log total health expenditures
Year of birth husband	0.001	−0.057
	(0.03)	(0.05)
Year of birth wife	−0.016	0.038
	(0.03)	(0.05)
Age husband	−0.001	−0.056
	(0.03)	(0.05)
Age wife	−0.01	0.046
	(0.03)	(0.05)
Wealth (in $10,000)	0.004***	0.002***
	(0.00)	(0.00)
Cesd score husband	0.003	−0.022
	(0.01)	(0.03)
Cesd score wife	−0.008	−0.029
	(0.01)	(0.02)
Any IADL limitations husband	0.021	−0.031
	(0.04)	(0.06)
Any IADL limitations wife	−0.051	−0.049
	(0.04)	(0.07)
Poor health husband	0.053	0.138**
	(0.05)	(0.07)
Poor health wife	0.01	−0.042
	(0.05)	(0.08)
Good health husband	−0.024	−0.03
	(0.04)	(0.06)
Good health wife	−0.002	−0.066
	(0.04)	(0.06)
Any ADL limitations husband	0.115*	0.01
	(0.06)	(0.10)
Any ADL limitations wife	0.072	0.027
	(0.06)	(0.09)
Years of education husband	0.01	0.027**
	(0.01)	(0.01)
Years of education wife	0.011	0.018
	(0.01)	(0.02)
Constant	29.90**	43.70**
	(12.73)	(18.45)
Number of observations (households)	1617 (524)	1606 (524)
Wald test on all health variables, p value	0.342	0.351

Robust standard errors in parentheses * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Next, we investigated the extent to which individuals' subjective mortality risk is associated with consumption growth at older ages. We first estimate the Euler equation as shown in Eq. (5) where consumption growth is explained by subjective mortality risk of elderly singles. In the first two models of Table 8 we have used all categories of nondurables whereas in the last two models we only included seven categories of nondurables as suggested by Salm (2010) (see Sect. 3.2). Also following Salm (2010), we included health indicators in levels in models (2) and (4). To allow for the possibility that individuals' marginal utility of consumption is affected by their health status (Börsch-Supan and Stahl 1991) we as well estimated models in which changes in individuals' health status are controlled for. Note that all explanatory variables are measured in the year between t and $t+1$ and, therefore, exogenous in the sense that they are not correlated with the error term in year $t+1$.

According this table, in all specifications the coefficient of subjective mortality risk has an expected sign but is only in model (4) statistically significant at the 10% level. The size of this latter estimate shows that an increase in subjective mortality by 1% point is associated with a decrease in consumption of about 0.34%. This estimate corresponds to a parameter of relative risk aversion which is equal to 2.9 which is in line with previous estimates in the literature (see, e.g. Skinner 1985; Palumbo 1999). While our findings suggest that consumption growth based on a subset of goods is lower for individuals with higher subjective mortality rates, as predicted by the life cycle model outlined in Sect. 2.1, subjective mortality risk does not explain consumption growth when based on all categories of nondurables. This may be because some of these categories such as home insurance, property tax, rent, electricity and water are not, or very slowly, adjusted in response to changes in the mortality risk.

The results in the fourth column also suggest that the growth rate of nondurable consumption is higher for the individuals who have any limitations in activities of daily living such as eating, bathing, walking etc. In other words, these individuals' current (nondurable) expenditures are smaller than their future expenditures. A reason for this finding can be that individuals who have limitations in daily activities would spend more money on health services and medical supplies and less money on other categories such as food, dining out, vacations and hobbies. The Salm (2010) categories of nondurables in model (4) exclude expenditures on health; therefore, we may find that the current expenditures on non-health related categories are lower for unhealthy individuals.

Table 9 shows for couples that although the coefficient on the couple's mortality rate has an expected sign in the first two models, it is not statistically significant. For the last two models we find an unexpected sign for the coefficient on the couple's mortality rate, yet these estimates are as well not statistically different from zero. The control variables also do not seem to play a role in determining the growth rate of consumption of elderly couples. Overall, these findings are not in support of the theoretical model for couples derived in Sect. 2.

4.1 Sensitivity Checks

Salm (2010) has suggested to instrument subjective mortality rate to account for measurement error that may be the result of rounding or focal point responses. Following

Table 8 Estimation of the Euler Eq. (5) by OLS for singles

Model	(1) Consumption growth (all categories)	(2) Consumption growth (all categories)	(3) Consumption growth (Salm 2010 categories)	(4) Consumption growth (Salm 2010 categories)
Ln (1-mortality rate)	0.119	0.17	0.294	0.343*
	(0.12)	(0.12)	(0.19)	(0.20)
Change in self-rated health	−0.005		−0.005	
	(0.01)		(0.01)	
Change in any ADL	0.027		0.019	
	(0.02)		(0.03)	
Change in any IADL	0.019		−0.022	
	(0.02)		(0.03)	
Change in CES-D	0.003		0.001	
	(0.00)		(0.01)	
Years of education	0.0003	0.001	−0.002	−0.001
	(0.00)	(0.00)	(0.00)	(0.00)
Poor health		0.023		−0.001
		(0.02)		(0.03)

Table 8 continued

Model	(1) Consumption growth (all categories)	(2) Consumption growth (all categories)	(3) Consumption growth (Salm 2010 categories)	(4) Consumption growth (Salm 2010 categories)
Good health		0.001		−0.001
		(0.02)		(0.02)
Any IADL limitations		0.003		−0.033
		(0.02)		(0.02)
Any ADL limitations		0.015		0.078**
		(0.02)		(0.03)
CES-D score		0.003		0.009
		(0.00)		(0.01)
Constant	−0.02	−0.046	0.006	−0.014
	(0.05)	(0.05)	(0.06)	(0.06)
Number of observations (households)	1306 (641)	1323 (646)	1306 (641)	1323 (646)
Wald test all health variables, p value	0.327	0.501	0.847	0.084

Robust standard errors are in parentheses * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Table 9 Estimation of Euler Eq. (11) by OLS for couples

Model	(1) Consumption growth (all categories)	(2) Consumption growth (all categories)	(3) Consumption growth (Salm 2010 categories)	(4) Consumption growth (Salm 2010 categories)
Ln (1-couple's mortality rate)	0.263	0.267	−0.064	−0.122
	(0.19)	(0.19)	(0.26)	(0.27)
Change in self health husband	0.011		0.018	
	(0.01)		(0.01)	
Change in self health wife	0.011		0.009	
	(0.01)		(0.01)	
Change in any ADL husband	0.023		−0.014	
	(0.03)		(0.04)	
Change in any ADL wife	0.013		−0.033	
	(0.03)		(0.03)	
Change in any IADL husband	0.0001		0.034*	
	(0.02)		(0.02)	
Change in any IADL wife	−0.009		−0.01	
	(0.02)		(0.02)	
Change in CES-D husband	−0.0004		0.003	
	(0.01)		(0.01)	
Change in CES-D wife	−0.001		0.002	
	(0.01)		(0.01)	

Table 9 continued

Model	(1) Consumption growth (all categories)	(2) Consumption growth (all categories)	(3) Consumption growth (Salm 2010 categories)	(4) Consumption growth (Salm 2010 categories)
Years of education husband	−0.0004	0.001	−0.002	−0.002
	(0.00)	(0.00)	(0.00)	(0.00)
Years of education wife	−0.001	−0.002	−0.005	−0.006
	(0.00)	(0.00)	(0.01)	(0.01)
Poor health husband		0.006		0.015
		(0.02)		(0.03)
Poor health wife		0.002		−0.022
		(0.02)		(0.03)
Good health husband		−0.026		0.004
		(0.02)		(0.02)
Good health wife		−0.009		−0.017
		(0.02)		(0.02)
Any IADL limitations husband		−0.003		0.03
		(0.02)		(0.02)
Any IADL limitations wife		−0.011		−0.012
		(0.02)		(0.03)

Table 9 continued

Model	(1) Consumption growth (all categories)	(2) Consumption growth (all categories)	(3) Consumption growth (Salm 2010 categories)	(4) Consumption growth (Salm 2010 categories)
Any ADL limitations husband		−0.018		−0.042
		(0.03)		(0.04)
Any ADL limitations wife		0.011		−0.024
		(0.03)		(0.04)
CES-D score husband		−0.003		−0.005
		(0.01)		(0.01)
CES-D score wife		−0.001		0.002
		(0.01)		(0.01)
Constant	−0.011	0.017	0.049	0.06
	(0.05)	(0.06)	(0.07)	(0.08)
Number of observations (households)	1004 (506)	1061 (524)	1004 (506)	1061 (524)
Wald test all health variables, p value	0.845	0.921	0.46	0.802

Robust standard errors are in parentheses * $p < 0.10$; ** $p < 0.05$; *** $p\,0.01$

Table 10 IV estimation results of the Euler Equation (single person households)

Model	(1) Consumption growth (Salm 2010 categories)	(2) Ln (1-mortality rate) (first stage)	(3) Consumption growth (Salm 2010 categories)	(4) Ln (1-mortality rate) (first stage)
Ln (1-mortality rate)	0.760*		0.873*	
	(0.43)		(0.47)	
Change in self-rated health	−0.005	−0.0003		
	(0.01)	(0.00)		
Change in any ADL	0.03	−0.013***		
	(0.03)	(0.00)		
Change in any IADL	−0.015	0.001		
	(0.02)	(0.00)		
Change in CES-D	0.001	0.0002		
	(0.01)	(0.00)		
Years of education	−0.003	0.001**	−0.002	0.001
	(0.00)	(0.00)	(0.00)	(0.00)
Ln (1-mortality rate), life table		0.705***		0.659***
		(0.06)		(0.06)
Mother is still alive (ref.)		–		–
Mother's age at death ≤ 76		−0.020**		−0.017*
		(0.01)		(0.01)

Table 10 continued

Model	(1) Consumption growth (Salm 2010 categories)	(2) Ln (1-mortality rate) (first stage)	(3) Consumption growth (Salm 2010 categories)	(4) Ln (1-mortality rate) (first stage)
Mother's age at death [77,84]		−0.009		−0.007
		(0.01)		(0.01)
Mother's age at death ≥ 85		−0.0005		0.001
		(0.01)		(0.01)
Poor health			0.019	−0.023***
			(0.03)	(0.00)
Good health			−0.007	0.010***
			(0.02)	(0.00)
Any IADL limitations			−0.03	0.002
			(0.02)	(0.00)
Any ADL limitations			0.085**	−0.005
			(0.03)	(0.00)
CES-D score			0.008	0.0003
			(0.01)	(0.00)
Constant	0.05	−0.039***	0.022	−0.031***
	(0.07)	(0.01)	(0.07)	(0.01)
Number of obs.(households)	1290 (630)	1290 (630)	1307 (635)	1307 (635)
F test statistic		47.30		41.77
Hansen's J test, p value		0.850		0.798
Test of exogeneity, p value		0.265		0.257

Robust standard errors in parentheses * $p < 0.10$; ** $p < 0.05$; *** p 0.01

Table 11 IV Estimation of the Euler Equation for couple households

Model	(1) Consumption growth (all categories)	(2) Ln (1-couple's mortality rate) (first stage)	(3) Consumption growth (all categories)	(4) Ln (1- couple's mortality rate) (first stage)
Ln (1-couple's mortality rate)	0.427		0.241	
	(0.43)		(0.47)	
Change in self health husband	0.011	−0.001		
	(0.01)	(0.00)		
Change in self health wife	0.011	−0.002		
	(0.01)	(0.00)		
Change in any ADL husband	0.023	0.001		
	(0.03)	(0.00)		
Change in any ADL wife	0.013	−0.002		
	(0.03)	(0.00)		
Change in any IADL husband	0.0003	−0.0003		
	(0.02)	(0.00)		
Change in any IADL wife	−0.009	0.001		
	(0.02)	(0.00)		
Change in CES-D husband	0	−0.002**		
	(0.01)	(0.00)		
Change in CES-D wife	−0.001	0.0003		
	(0.01)	(0.00)		
Years of education husband	−0.001	0.001**	0.001	0.0001
	(0.00)	(0.00)	(0.00)	(0.00)
Years of education wife	−0.001	0.0006	−0.002	0.00001
	(0.00)	(0.00)	(0.00)	(0.00)

Table 11 continued

Model	(1) Consumption growth (all categories)	(2) Ln (1-couple's mortality rate) (first stage)	(3) Consumption growth (all categories)	(4) Ln (1- couple's mortality rate) (first stage)
Ln (1-couple's mortality rate), life table		0.833***		0.765***
		(0.07)		(0.07)
Poor health husband			0.006	−0.010***
			(0.02)	(0.00)
Poor health wife			0.002	−0.006*
			(0.03)	(0.00)
Good health husband			−0.026	0.004*
			(0.02)	(0.00)
Good health wife			−0.009	0.008***
			(0.02)	(0.00)
Any IADL limitations husband			−0.003	0.001
			(0.02)	(0.00)
Any IADL limitations wife			−0.011	−0.001
			(0.02)	(0.00)

Table 11 continued

Model	(1) Consumption growth (all categories)	(2) Ln (1-couple's mortality rate) (first stage)	(3) Consumption growth (all categories)	(4) Ln (1- couple's mortality rate) (first stage)
Any ADL limitations husband			−0.018	−0.006*
			(0.03)	(0.00)
Any ADL limitations wife			0.011	−0.002
			(0.03)	(0.00)
CES-D score husband			−0.003	−0.003***
			(0.01)	(0.00)
CES-D score wife			−0.001	−0.0004
			(0.01)	(0.00)
Constant	0.0002	−0.036***	0.016	−0.017**
	(0.06)	(0.01)	(0.06)	(0.01)
Number of observations (households)	1004 (506)	1004 (506)	1061 (524)	1061 (524)
Test of exogeneity, p value		0.689		0.954

Robust standard errors are in parentheses * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Salm (2010), we have used mother's age at death as an instrument as well as the respondent's life table mortality rate.[8] According to the first stage results in columns (2) and (4) of Table 10, life table mortality rate is strongly correlated with subjective mortality rate. The Hansen's J statistics at the bottom of the table suggest that the (overidentifying) instruments are exogenous in the sense that they are not correlated with the error term of the consumption growth equation. The partial F-statistics for models (2) and (4) are quite high (more than 10) which suggests sufficient strength of the relationship between subjective mortality rate and the additional instruments in the first stage regressions. The last row in this table reports Wooldridge's (1995) robust score test statistic to determine whether the subjective mortality rate can be considered exogenous. The outcome of this test indicates that exogeneity of the subjective mortality rate cannot be rejected which suggests that IV estimation is not needed and we may rely on the OLS results of Table 8.

Table 11 shows the IV estimation results of the Euler equation for couples. We instrument the couple's mortality rate with the couple's mortality rate based on individual mortality rates from life tables. We do not use mother's age at death as an instrument because it did not significantly predict couple's mortality risk. According to the first stage results in columns (2) and (4), the couple's mortality risk obtained from the life table is strongly correlated with the couple's mortality rate based on subjective mortality risks of the husband and the wife. The second stage results in columns (1) and (3) show that the coefficients on the couple's adjusted mortality rate have the expected positive sign, yet they are not statistically significant. In line with the estimation results in Table 9 we find that the prediction of the life-cycle model for elderly couples does not hold even after accounting for measurement error in subjective survival probabilities of the husband and the wife.

5 Conclusions

Previous studies have found that individuals do not draw down their assets after retirement which is at odds with the predictions of a simple life cycle model without uncertainty. Hurd (1989, 1999) explain saving behavior of elderly singles and couples by adding lifetime uncertainty and bequest motives to the simple life cycle model. We have tested in this paper the predictions of the models proposed by Hurd (1989, 1999) for elderly Americans using data from the Health and Retirement Study (HRS) supplemented with data from the Consumption and Activities Mail Survey (CAMS).

We found that more than half of the individuals in our sample spend more than their annuity income after retirement which indicates most individuals have decreasing wealth profiles in old age as predicted by the theory. Moreover, we found that the difference between total consumption and annuity income increases with the level of wealth for both elderly singles and couples. We found for single person households that the growth rate of consumption expenditures on sub-categories of nondurables is lower for individuals with higher subjective mortality rates. The subjective mortality risk does

[8] We found that father's age of death does not significantly predict individuals' subjective mortality risk and to avoid using too many insignificant instruments we therefore did not use it.

not, however, explain the growth rate of consumption expenditures on all categories of nondurables and this may be because some of these expenditure categories such as home insurance, property tax, rent, electricity, water or heating are not adjusted in response to changes in mortality risk. The growth rate of consumption of elderly couples does not depend on their mortality risk, contrary to the theoretical prediction. A possible explanation for this latter finding is that the assumption of the model regarding the same coefficient of relative risk aversion for both spouses may not be supported by the empirical evidence since women tend to be more risk averse than men in financial decision-making (see, e.g. Croson and Gneezy 2009).

Overall this paper has presented some empirical evidence in favor of wealth decumulation by the elderly after retirement. Future research can, for instance, explore an extension of the life cycle model for couples by assuming a different coefficient of relative risk aversion for the husband and the wife. This may as well require, in contrast to what we did, estimating the risk aversion parameters. In addition, the importance of the assumption that the death of the husband is independent of the death of the wife should be further investigated. Another extension of our model would be adding additional uncertainty to the model such as uncertainty about out-of-pocket medical expenses which could be an important factor to explain savings of the elderly in the United States.

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